

Chapter 5

Electricity

World electricity generation increases by 87 percent from 2007 to 2035 in the IEO2010 Reference case. Non-OECD countries account for 61 percent of world electricity use in 2035.

Overview

World net electricity generation increases by an average of 2.3 percent per year from 2007 to 2035 in the IEO2010 Reference case. Electricity supplies an increasing share of the world's total energy demand and grows faster than liquid fuels, natural gas, and coal in all end-use sectors except transportation. From 1990 to 2007, growth in net electricity generation outpaced the growth in total energy consumption (1.9 percent per year and 1.3 percent per year, respectively), and the growth in demand for electricity continues to outpace growth in total energy use throughout the projection period (Figure 67).

World net electricity generation increases by 87 percent in the Reference case, from 18.8 trillion kilowatthours in 2007 to 25.0 trillion kilowatthours in 2020 and 35.2 trillion kilowatthours in 2035 (Table 11). Although the recent economic downturn slowed the rate of growth in electricity use in 2008 and resulted in no change in electricity use in 2009, the Reference case projection expects growth in electricity use to return to pre-recession trend rates by 2015.

The impact of the recession on electricity consumption has been felt most keenly in the industrial sector. Demand in the building sector (the residential and commercial sectors) is less sensitive to changing economic conditions than it is in the industrial sector, because

people generally continue to consume electricity for space heating and cooling, cooking, refrigeration, lighting, and water heating, even in a recession.

In general, projected growth in OECD countries, where electricity markets are well established and consumption patterns are mature, is slower than in non-OECD countries, where a large amount of demand goes unmet at present. The electrification of historically off-grid areas plays a strong role in projected growth trends. The International Energy Agency estimates that 22 percent of the world's population did not have access to electricity in 2008—a total of about 1.5 billion people [1]. Regionally, sub-Saharan Africa is worst off: more than 71 percent of the population currently remains without access to power. With strong economic growth and targeted government programs, however, electrification can occur quickly. In Vietnam, for example, the government's rural electrification program increased access to power from 51 percent of rural households in 1996 to 95 percent by the end of 2008 [2].

Non-OECD nations consumed 46 percent of the world's total electricity supply in 2007, and their share of world consumption is poised to increase over the projection period. In 2035, non-OECD nations account for 61 percent of world electricity use, while the OECD share declines to 39 percent (Figure 68). Total net electricity

Figure 67. Growth in world electric power generation and total energy consumption, 1990-2035 (index, 1990 = 1)

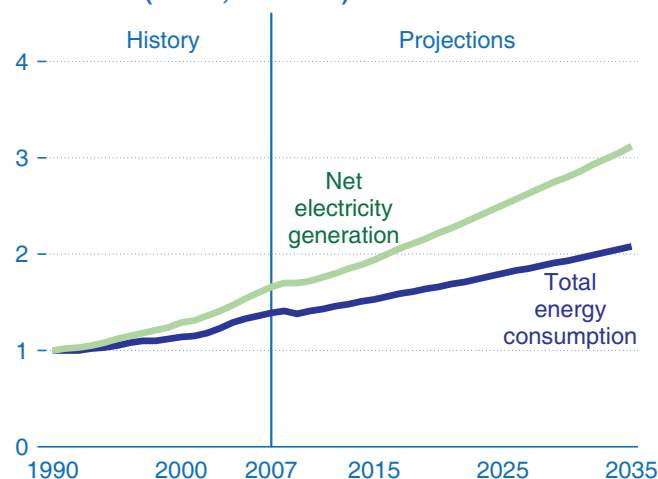
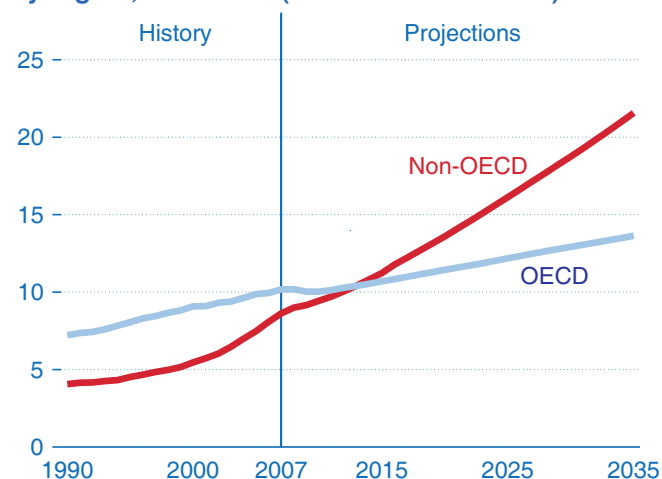
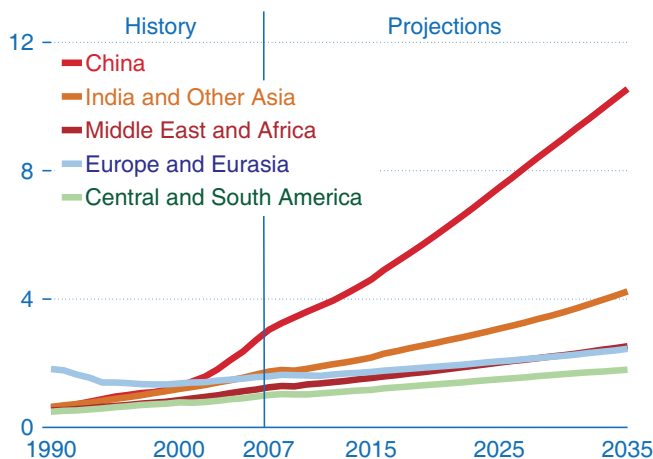


Figure 68. World net electricity generation by region, 1990-2035 (trillion kilowatthours)



generation in non-OECD countries increases by an average of 3.3 percent per year in the Reference case, led by non-OECD Asia (including China and India), with annual increases averaging 4.1 percent from 2007 to 2035 (Figure 69). In contrast, net generation among OECD nations grows by an average of only 1.1 percent per year from 2007 to 2035.

Figure 69. Non-OECD net electricity generation by region, 1990-2035 (trillion kilowatthours)



The Reference case does not include any carbon emissions caps or prices. However, the *IEO2010* Reference case does incorporate national energy policies that are currently active, such as the European Union's "20-20-20" plan and its member states' nuclear policies; China's wind capacity targets; and India's National Solar Mission.

The projection for total electricity generation in 2030 is 0.3 percent lower in the *IEO2010* Reference case than it was in last year's outlook, largely because the impact of the recession in the near term was more severe than anticipated in last year's projection. Compared with *IEO2009*, the generation mix in 2030 in *IEO2010* also changes. For example, liquids-fired generation is 11 percent lower than in *IEO2009*, both natural gas and coal-fired generation are about 5 percent higher, nuclear power generation is 9 percent higher, and generation from renewable sources is 10 percent higher.

Electricity supply by energy source

The mix of primary fuels used to generate electricity has changed a great deal over the past four decades on a worldwide basis. Coal continues to be the fuel most widely used for electricity generation, although

Table 11. OECD and Non-OECD net electricity generation by energy source, 2007-2035 (trillion kilowatthours)

Region	2007	2015	2020	2025	2030	2035	Average annual percent change, 2007-2035
OECD							
Liquids	0.3	0.3	0.3	0.3	0.3	0.2	-1.0
Natural gas	2.2	1.9	2.2	2.5	2.9	3.1	1.4
Coal	3.9	3.8	3.8	3.8	4.0	4.2	0.3
Nuclear	2.2	2.4	2.5	2.6	2.7	2.8	1.0
Renewables	1.6	2.3	2.6	2.9	3.1	3.2	2.5
Total OECD	10.1	10.7	11.4	12.2	12.9	13.6	1.1
Non-OECD							
Liquids	0.6	0.6	0.5	0.5	0.5	0.6	-0.2
Natural gas	1.7	2.2	2.8	3.2	3.6	3.7	2.8
Coal	4.1	5.1	6.0	7.3	9.0	10.8	3.6
Nuclear	0.4	0.7	1.0	1.3	1.5	1.7	5.0
Renewables	1.8	2.7	3.2	3.7	4.3	4.8	3.5
Total Non-OECD	8.6	11.2	13.6	16.1	18.8	21.6	3.3
World							
Liquids	0.9	0.9	0.8	0.8	0.8	0.8	-0.4
Natural gas	3.9	4.2	5.0	5.8	6.4	6.8	2.1
Coal	7.9	8.8	9.8	11.2	12.9	15.0	2.3
Nuclear	2.6	3.1	3.6	3.9	4.2	4.5	2.0
Renewables	3.5	5.0	5.8	6.6	7.3	8.0	3.0
Total World	18.8	21.9	25.0	28.3	31.6	35.2	2.3

Note: Totals may not equal sum of components due to independent rounding.

generation from nuclear power increased rapidly from the 1970s through the 1980s, and natural-gas-fired generation grew rapidly in the 1980s and 1990s. The use of oil for electricity generation has been declining since the mid-1970s, when oil prices rose sharply.

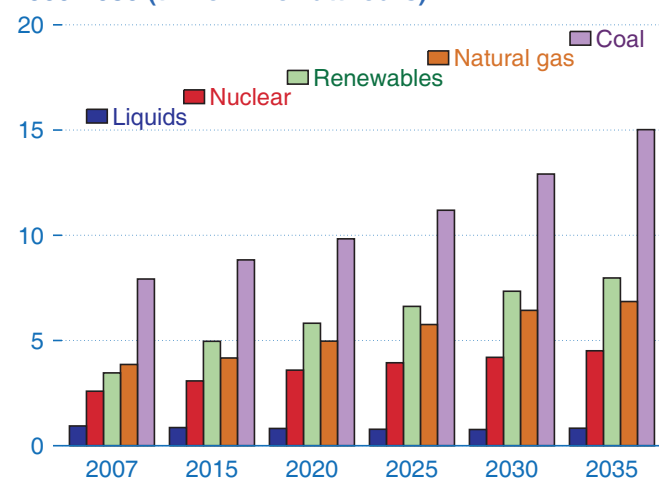
High fossil fuel prices recorded between 2003 and 2008, combined with concerns about the environmental consequences of greenhouse gas emissions, have renewed interest in the development of alternatives to fossil fuels—specifically, nuclear power and renewable energy sources. In the *IEO2010* Reference case, long-term prospects continue to improve for generation from both nuclear and renewable energy sources—supported by government incentives and by high fossil fuel prices. Coal and natural gas are the second and third fastest-growing sources of energy for electricity generation in the projection (Table 11), but the outlook for coal, in particular, could be altered substantially by any future national policies or international agreements that aim to reduce or limit the growth of greenhouse gas emissions.

Coal

In the *IEO2010* Reference case, coal continues to fuel the largest share of worldwide electric power production by a wide margin (Figure 70). In 2007, coal-fired generation accounted for 42 percent of world electricity supply; in 2035, its share increases slightly to 43 percent. Sustained high prices for oil and natural gas make coal-fired generation more attractive economically, particularly in nations that are rich in coal resources, including China and India. World net coal-fired generation nearly doubles over the projection period, from 7.9 trillion kilowatthours in 2007 to 15.0 trillion kilowatthours in 2035.

The outlook for coal-fired generation could be altered substantially by national policies or international agreements to reduce greenhouse gas emissions. The electric

Figure 70. World net electricity generation by fuel, 2006-2030 (trillion kilowatthours)



power sector offers some of the most cost-effective opportunities for reducing carbon dioxide emissions in many countries. Coal is both the world's most widely used source of energy for power generation and also the most carbon-intensive energy source. If a cost, either implicit or explicit, were applied to carbon dioxide emissions, there are several alternative no- or low-emission technologies that currently are commercially proven or under development, which could be used to replace some coal-fired generation. Implementing the technologies would not require expensive, large-scale changes in the power distribution infrastructure or in electricity-using equipment.

Natural gas

Over the 2007 to 2035 projection period, natural-gas-fired electricity generation increases by 2.1 percent per year. Generation from natural gas worldwide increases from 3.9 trillion kilowatthours in 2007 to 6.8 trillion kilowatthours in 2035, but the total amount of electricity generated from natural gas continues to be less than one-half the total for coal, even in 2035. Natural-gas-fired combined-cycle technology is an attractive choice for new power plants because of its fuel efficiency, operating flexibility (it can be brought online in minutes rather than the hours it takes for coal-fired and some other generating capacity), relatively short planning and construction times, relatively low emissions, and relatively low capital costs.

Liquid fuels and other petroleum

With world oil prices projected to return to relatively high levels, reaching \$133 per barrel (in real 2008 dollars) in 2035, liquid fuels are the only energy source for power generation that does not grow on a worldwide basis. Most nations are expected to respond to higher oil prices by reducing or eliminating their use of oil for generation—opting instead for more economical sources of electricity, including coal and nuclear. Generation from liquid fuels decreases by 0.4 percent per year, from 0.9 trillion kilowatthours in 2007 to 0.8 trillion kilowatthours in 2035. Modest growth in liquid fuels generation in the later years of the projection, particularly in the Middle East, is more than offset by decline in all other regions.

Nuclear power

Electricity generation from nuclear power increases from about 2.6 trillion kilowatthours in 2007 to 4.5 trillion kilowatthours in 2035, as concerns about rising fossil fuel prices, energy security, and greenhouse gas emissions support the development of new nuclear generation capacity. High prices for fossil fuels allow nuclear power to become economically competitive with generation from coal, natural gas, and liquid fuels despite the relatively high capital costs associated with

nuclear power plants. Moreover, higher capacity utilization rates have been reported for many existing nuclear facilities, and it is anticipated that most of the older nuclear power plants in the OECD countries and non-OECD Eurasia will be granted extensions to their operating lives.

Around the world, nuclear generation is attracting new interest as countries look to increase the diversity of their energy supplies and provide a low-carbon alternative to fossil fuels. Still, there is considerable uncertainty associated with nuclear power projections. Issues that could slow the expansion of nuclear power in the future include plant safety, radioactive waste disposal, rising construction costs and investment risk, and concerns that weapons-grade uranium may be produced from centrifuges installed to enrich uranium for civilian nuclear power programs. These issues continue to raise public concern in many countries and may hinder the development of new nuclear power reactors. Nevertheless, the *IEO2010* Reference case incorporates improved prospects for world nuclear power. The projection for nuclear electricity generation in 2030 is 9 percent higher than the projection published in last year's outlook.

On a regional basis, the *IEO2010* Reference case projects the strongest growth in nuclear power for the countries of non-OECD Asia (Figure 71). Non-OECD Asia's nuclear power generation grows at an average annual rate of 7.7 percent from 2007 to 2035, including increases of 8.4 percent per year in China and 9.5 percent per year in India. China leads the field with nearly 43 percent of worldwide active construction projects in 2009 and is expected to install the most nuclear capacity over the period, building 66 gigawatts of net generation capacity by 2035 [3]. Outside Asia, nuclear generation grows the fastest in Central and South America, where it increases

by an average of 4.3 percent per year. The nuclear generation forecast in OECD Europe has undergone a significant revision from *IEO2009*, because multiple countries in the region are reversing their anti-nuclear policies. In the *IEO2010* Reference case, nuclear generation worldwide increases by 2.0 percent per year.

To address the uncertainty inherent in projections of nuclear power growth in the long term, a two-step approach is used to formulate the outlook for nuclear power. In the short term (through 2020), projections are based primarily on the current activities of the nuclear power industry and national governments. Because of the long permitting and construction lead times associated with nuclear power plants, there is general agreement among analysts on which nuclear projects are likely to become operational in the short-term. After 2020, the projections are based on a combination of announced plans or goals at the country and regional levels and consideration of other issues facing the development of nuclear power, including economics, geopolitical issues, technology advances, environmental policies, and uranium availability.

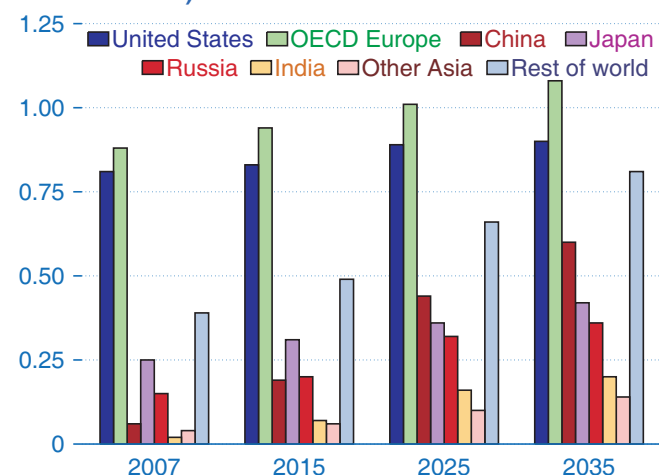
Hydroelectric, wind, geothermal, and other renewable generation

Renewable energy is the fastest-growing source of electricity generation in the *IEO2010* Reference case. Total generation from renewable resources increases by 3.0 percent annually, and the renewable share of world electricity generation grows from 18 percent in 2007 to 23 percent in 2035. Almost 80 percent of the increase is in hydroelectric power and wind power. The contribution of wind energy, in particular, has grown swiftly over the past decade, from 18 gigawatts of net installed capacity at the end of 2000 to 159 gigawatts at the end of 2009—a trend that continues into the future [4]. Of the 4.5 trillion kilowatthours of new renewable generation added over the projection period, 2.4 trillion kilowatthours (54 percent) is attributed to hydroelectric power and 1.2 trillion kilowatthours (26 percent) to wind (Table 12).

Although renewable energy sources have positive environmental and energy security attributes, most renewable technologies other than hydroelectricity are not able to compete economically with fossil fuels during the projection period outside of a few regions. Solar power, for instance, is currently a “niche” source of renewable energy but can be economical where electricity prices are especially high, where peak load pricing occurs, or where government incentives are available. Government policies or incentives often provide the primary economic motivation for construction of renewable generation facilities.

Wind and solar are intermittent technologies that can be used only when resources are available. Once built, the cost of operating wind or solar technologies when the

Figure 71. World net electricity generation from nuclear power by region, 2007-2030 (trillion kilowatthours)



resource is available is generally much less than the cost of operating conventional renewable generation. However, high construction costs can make the total cost to build and operate renewable generators higher than those for conventional power plants. The intermittence of wind and solar can further hinder the economic competitiveness of those resources, as they are not operator-controlled and are not necessarily available when they would be of greatest value to the system. The use of energy storage (such as hydroelectric pumped storage, compressed air storage, and batteries) and a wide geographic dispersal of wind and solar generating facilities could mitigate many of the problems associated with intermittence in the future.

Changes in the mix of renewable fuels used for electricity generation differ between the OECD and non-OECD regions in the *IEO2010* Reference case. In OECD nations, the majority of economically exploitable hydroelectric resources already have been captured; with the exceptions of Canada and Turkey, there are few large-scale hydroelectric projects planned for the future. As a result, most renewable energy growth in OECD countries

comes from nonhydroelectric sources, especially wind and biomass. Many OECD countries, particularly those in Europe, have government policies, including feed-in tariffs,²¹ tax incentives, and market share quotas, that encourage the construction of renewable electricity facilities.

In non-OECD countries, hydroelectric power is expected to be the predominant source of renewable electricity growth. Strong growth in hydroelectric generation, primarily from mid- to large-scale power plants, is expected in China, India, Brazil, and a number of nations in Southeast Asia, including Malaysia and Vietnam. Growth rates for wind-powered generation are also high in non-OECD countries. The most substantial additions of electricity supply generated from wind power are centered in China.

The *IEO2010* projections for renewable energy sources include only marketed renewables. Non-marketed (non-commercial) biomass from plant and animal resources, while an important source of energy, particularly in the developing non-OECD economies, is not included in the

Table 12. OECD and Non-OECD net renewable electricity generation by energy source, 2007-2035 (billion kilowatthours)

Region	2007	2015	2020	2025	2030	2035	Average annual percent change, 2007-2035
OECD							
Hydropower	1,246	1,384	1,460	1,530	1,585	1,624	0.9
Wind	144	525	671	803	846	898	6.8
Geothermal	37	57	61	66	73	80	2.8
Solar	6	85	104	107	114	122	11.6
Other	195	253	318	398	456	485	3.3
Total OECD	1,628	2,303	2,614	2,904	3,074	3,208	2.5
Non-OECD							
Hydropower	1,753	2,305	2,706	3,061	3,449	3,795	2.8
Wind	21	157	231	312	388	457	11.7
Geothermal	21	41	47	52	68	80	5.0
Solar	0	10	23	33	39	44	21.7
Other	40	141	196	255	317	389	8.4
Total Non-OECD	1,834	2,654	3,203	3,714	4,263	4,764	3.5
World							
Hydropower	2,999	3,689	4,166	4,591	5,034	5,418	2.1
Wind	165	682	902	1,115	1,234	1,355	7.8
Geothermal	57	98	108	119	142	160	3.7
Solar	6	95	126	140	153	165	12.7
Other	235	394	515	653	773	874	4.8
Total World	3,462	4,958	5,817	6,618	7,336	7,972	3.0

Note: Totals may not equal sum of components due to independent rounding.

²¹ A feed-in tariff is a financial incentive that encourages the adoption of renewable electricity. Under a feed-in tariff, government legislation requires electric utilities to purchase renewable electricity at a higher price than the wholesale price. This allows the renewable generator to achieve a positive return on its investment despite the higher costs associated with these resources.

projections because comprehensive data on its use are not available. Off-grid distributed renewables (renewable energy consumed at the site of production, such as off-grid photovoltaic panels) are not included in the projections for the same reason.

Regional electricity outlooks

In the *IEO2010* Reference case, the highest growth rates for electricity generation are in non-OECD nations, where strong economic growth and rising personal incomes drive the growth in demand for electric power. In OECD countries—where electric power infrastructures are relatively mature, national populations generally are expected to grow slowly or decline, and GDP growth is slower than in the developing nations—demand for electricity grows much more slowly. In the Reference case, electricity generation in non-OECD nations increases by 3.3 percent per year, as compared with 1.1 percent per year in OECD nations.

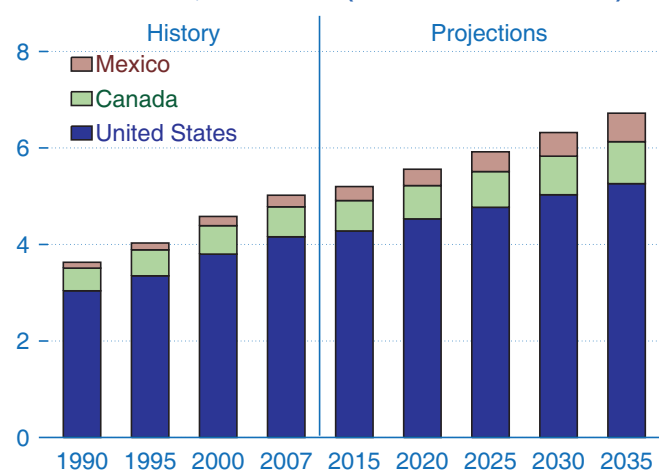
OECD electricity

North America

North America currently accounts for the largest regional share of world electricity generation, with 27 percent of the total in 2007. That share declines as non-OECD nations experience fast-paced growth in demand for electric power. In 2035, North America accounts for only 19 percent of the world's net electric power generation.

The United States is by far the largest consumer of electricity in North America (Figure 72). U.S. electricity generation—including both generation by electric power producers and on-site generation—increases slowly, at an average annual rate of 0.8 percent from 2007 to 2035. Canada, like the United States, has a mature electricity market, and its generation increases by 1.2 percent per year over the same period. Mexico's electricity

Figure 72. Net electricity generation in North America, 1990-2035 (trillion kilowatthours)

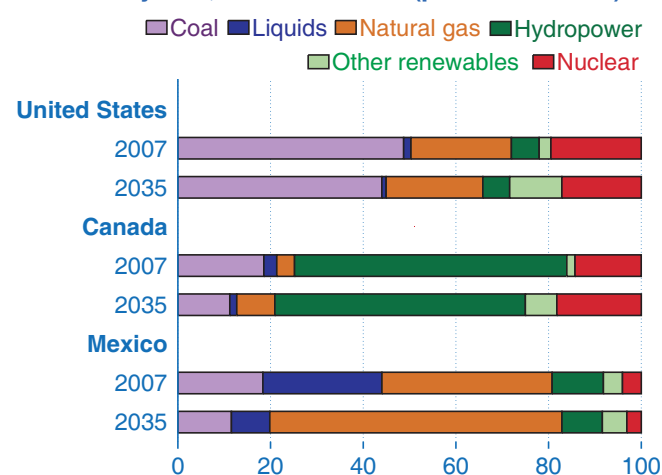


generation grows at a faster rate—averaging 3.2 percent per year through 2035—reflecting the present less-developed state of the country's electric power infrastructure (and thus the greater potential for expansion) relative to Canada and the United States.

There are large differences in the mix of energy sources used to generate electricity in the three countries that make up OECD North America, and those differences are likely to become more pronounced in the future (Figure 73). In the United States, coal is the leading source of energy for power generation, accounting for 49 percent of the 2007 total. In Canada, hydroelectricity provided 59 percent of the nation's electricity generation in 2007. Most of Mexico's electricity generation is currently fueled by petroleum-based liquid fuels and natural gas, which together accounted for 63 percent of its total electricity generation in 2007. In the Reference case, U.S. reliance on coal decreases to 44 percent in 2035; Canada's hydropower continues to be the predominant energy source for electricity generation, although its share of the total falls to 54 percent in 2035; and the natural gas share of Mexico's total electricity generation increases from 37 percent in 2007 to 63 percent in 2035.

Generation from renewable energy sources in the United States increases in response to requirements in more than half of the 50 States for minimum renewable generation or capacity shares. Renewable generation in the *IEO2010* Reference case is substantially higher than in recent *IEO* projections, as the share of generation coming from renewable energy sources grows from 8.5 percent in 2007 to 17.0 percent in 2035. Net installed capacity of wind power increased by 39 percent, equal to nearly 10 gigawatts, in 2009 alone [5]. The American Recovery and Reinvestment Act of 2009 directed \$16.8 billion into energy efficiency and renewable energy and another \$4.0 billion into loan guarantees for renewable energy [6]. U.S. federal subsidies for renewable generation are assumed to expire as enacted. If those subsidies

Figure 73. Net electricity generation in North America by fuel, 2007 and 2035 (percent of total)



were extended, however, a larger increase in renewable generation would be expected.

Electricity generation from nuclear power plants accounts for 17.1 percent of total U.S. generation in 2035 in the *IEO2010* Reference case. From 2007 to 2035, the United States adds 8.4 gigawatts of new capacity and 4.0 gigawatts from expansions at existing plants. No U.S. nuclear plants are retired in the Reference case. Despite the increasing estimated costs of new nuclear plants, growth in nuclear power is expected to be spurred by the rising costs of natural-gas-fired generation, concerns about greenhouse gas emissions (which limit additions of coal-fired plants in the projection), and favorable U.S. policies.

In Canada, generation from natural gas increases by 4.0 percent per year from 2007 to 2035, nuclear by 2.1 percent per year, hydroelectricity by 0.9 percent per year, and wind by 10.7 percent per year. Oil-fired generation and coal-fired generation, on the other hand, decline by 1.0 percent per year and 0.6 percent per year, respectively.

In Ontario—Canada’s largest provincial electricity consumer—the government plans to close its four coal-fired plants (Atikokan, Lambton, Nanticoke, and Thunder Bay) by December 31, 2014, citing environmental and health concerns [7]. Units 1 and 2 of Lambton and units 3 and 4 of Nanticoke are scheduled to be decommissioned by the end of 2010 [8]. The government plans to replace coal-fired generation with natural gas, nuclear, hydro-power, and wind. It also plans to increase conservation measures. At present, coal provides about 19 percent of Ontario’s electric power. With the planned retirements in Ontario, Canada’s coal-fired generation declines from about 115 billion kilowatthours in 2007 to 97 billion kilowatthours in 2035.

The renewable share of Canada’s overall generation remains roughly constant throughout the projection. Hydroelectric power is, and is expected to remain, the primary source of electricity in Canada. In 2007, hydroelectric generation provided 59 percent of the country’s total generation; it falls to 54 percent in 2035. Wind-powered generation, in contrast, is the fastest growing source of new energy in Canada; its share increases from 1 percent to 6 percent over the projection period.

As one of the few OECD countries with large untapped hydroelectric potential, Canada currently has several large- and small-scale hydroelectric facilities either planned or under construction. Hydro-Québec is continuing the construction of a 768-megawatt facility near Eastmain and a smaller 150-megawatt facility at Sarcelle in Québec, both of which are expected to be fully commissioned by 2012 [9]. Other hydroelectric projects

are under construction, including the 1,550-megawatt Romaine River project in Québec and the 200-megawatt Wuskwatim project in Manitoba [10]. The *IEO2010* Reference case does not anticipate that all planned projects will be constructed, but given Canada’s past experience with hydropower and the commitments for construction, new hydroelectric capacity accounts for 22,910 megawatts of additional renewable capacity added in Canada between 2007 and 2035.

Canada also has plans to continue expanding its wind power capacity. From 3.1 gigawatts of installed capacity at the end of 2009 [11], the total increases to nearly 17.5 gigawatts in 2035 in the Reference case. Growth in wind capacity has been so rapid that Canada’s federal wind incentive program, “ecoENERGY for Renewable Power,” which targeted the deployment of 4 gigawatts of renewable energy by 2011, allocated all of its funding and met its target by the end of 2009 [12].

In addition to the incentive programs of Canada’s federal government, several provincial governments have instituted their own incentives to support the construction of new wind capacity. Ontario’s Renewable Energy Standard Offer Program has helped support robust growth in wind installations over the past several years, and installed wind capacity in the province has risen from 0.6 megawatts in 1995 to 1,168 megawatts in January 2010 [13]. The Standard Offer Program pays all small renewable energy generators (those with installed capacity less than 10 megawatts) 11 cents (Canadian) per kilowatthour of electricity delivered to local electricity distributors [14]. Continued support from Canada’s federal and provincial governments—along with the sustained higher fossil fuel prices in the *IEO2010* Reference case—is expected to provide momentum for the projected increase in the country’s use of wind power for electricity generation.

Mexico’s electricity generation increases by an average of 3.2 percent annually from 2007 to 2035—more than double the rate for Canada and almost quadruple the rate for the United States. The Mexican government has recognized the need for the country’s electricity infrastructure to keep pace with the fast-paced growth anticipated for electricity demand. In July 2007, the government unveiled its 2007-2012 National Infrastructure Program, which included plans to invest \$25.3 billion to improve and expand electricity infrastructure [15]. As part of the program, the government has set a goal to increase installed generating capacity by 8.6 gigawatts from 2006 to 2012. The country is well on its way to meeting the government target. The 1,135-megawatt Tamazunchale combined-cycle plant became operational in June 2007, and several other plants under construction will bring on line another 1,304 megawatts in 2010 and 750 megawatts in 2012 [16].

Most of the increase in Mexico's electricity generation in the *IEO2010* Reference case is fueled by natural gas, as the Mexican government implements plans to reduce the country's use of diesel and fuel oil in the power sector [17]. Natural-gas-fired generation is more than quadrupled in the projection, from 90 billion kilowatthours in 2007 to 369 billion kilowatthours in 2035. The resulting growth in Mexico's demand for natural gas strongly outpaces its growth in production, leaving the country dependent on pipeline imports from the United States and LNG from other countries. Currently, Mexico has one LNG import terminal, Altamira, operating on the Gulf Coast and another, Costa Azul, on the Pacific Coast. A contract tender for a third terminal at Manzanillo, also on the Pacific Coast, was awarded in March 2008, and the project is scheduled for completion by 2011 [18].

Although much of the growth in Mexico's electric power sector is expected to be in the form of natural-gas-fired generation, renewable energy resources are the second fastest-growing source of generation in the projection. Mexico's renewable generation increases by 2.9 percent per year from 2007 to 2035, compared with 5.2 percent per year for natural-gas-fired generation. The country's current renewable generation energy mix is split largely between hydroelectricity (73 percent) and geothermal energy (19 percent). Two major hydroelectric projects are underway: the 750-megawatt La Yesca facility, scheduled for completion by 2012, and the planned 900-megawatt La Parota project, which has been delayed and may not be completed until 2018[19]. In the *IEO2010* Reference case, hydroelectric power increases by 2.3 percent per year and accounts for more than 60 percent of Mexico's total net generation from renewable energy sources in 2035.

Although there is virtually no wind or solar generation in Mexico at present, the Mexican government's goal of installing 2.5 gigawatts of wind capacity on the Tehuantepec Isthmus by 2012 is expected to encourage wind development in the short term [20]. Furthermore, Mexico's goal of reducing national greenhouse gas emissions to 50 percent of the 2002 levels by 2050 will spur wind and solar installations, and those two forms of renewable electricity account for double-digit growth over the projection period [21]. Their combined share of total renewable electricity generation rises from less than 1 percent in 2007 to 10 percent in 2035.

OECD Europe

Electricity generation in the nations of OECD Europe increases by an average of 1.1 percent per year in the *IEO2010* Reference case, from 3.4 trillion kilowatthours in 2007 to 4.4 trillion kilowatthours in 2030 and 4.6 trillion kilowatthours in 2035. Because most of the countries in OECD Europe have relatively stable populations and mature electricity markets, most growth in electricity

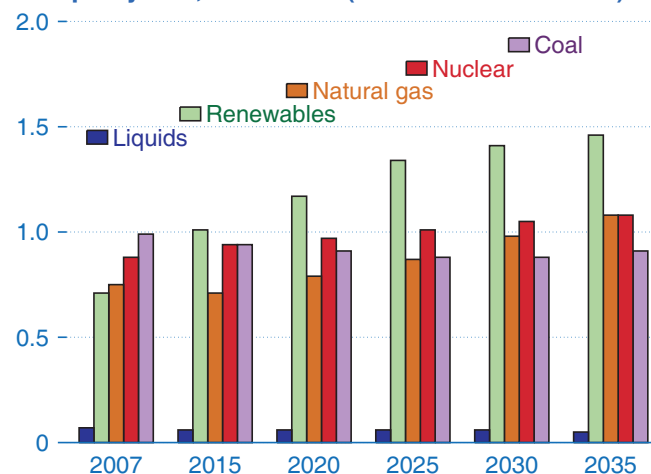
demand is expected to come from those nations with more robust population growth (including Turkey, Ireland, and Spain) and from the newest OECD members (including the Czech Republic, Hungary, and Poland), whose economic growth rates exceed the OECD average through the projection period. In addition, as environmental concerns remain prominent in the region, there is a concerted effort in the industrial sector to switch from coal and liquid fuels to electricity.

Renewable energy is OECD Europe's fastest-growing source of electricity generation in the Reference case (Figure 74), growing by 2.6 percent per year through 2035. The increase is almost entirely from nonhydropower sources. OECD Europe's leading position worldwide in wind power capacity is maintained through 2035, with growth in generation from wind sources averaging 6.5 percent per year, even though the Reference case assumes no enactment of additional legislation to limit greenhouse gas emissions. Strong growth in offshore wind capacity is currently underway, with 577 megawatts added to the grid in 2009, representing an increase of 54 percent over capacity added in 2008 [22].

The growth of nonhydropower renewable energy sources in OECD Europe is encouraged by some of the world's most favorable renewable energy policies. The European Union has set a binding target to produce 21 percent of electricity generation from renewable sources by 2010 [23] and has reaffirmed the goal of increasing renewable energy use with its December 2008 "climate and energy policy," which mandates that 20 percent of total energy production must come from renewables by 2020 [24]. Approximately 21 percent of the European Union's electricity came from renewable sources in 2007.

The *IEO2010* Reference case does not anticipate that all future renewable energy targets in the European Union will be met on time. Nevertheless, current laws are

Figure 74. Net electricity generation in OECD Europe by fuel, 2007-2035 (trillion kilowatthours)



expected to lead to the construction of more renewable capacity than would have occurred in their absence. In addition, some individual countries provide economic incentives to promote the expansion of renewable electricity. Germany, Spain, and Denmark—the leaders in OECD Europe’s installed wind capacity—have enacted feed-in tariffs (FITs) that guarantee above-market rates for electricity generated from renewable sources and, typically, last for 20 years after a project’s completion. As long as European governments support such price premiums for renewable electricity, robust growth in renewable generation is likely to continue.

There have been drawbacks, however, to relying on FITs. Spain’s generous solar subsidy led to an overabundance of solar photovoltaic (PV) projects in the country in 2008, overheating the global PV market and committing Spanish taxpayers to an estimated \$26.5 billion to cover the total FIT costs over the lifetime of the projects. When the Spanish FIT was lowered after September 2008, a PV supply glut resulted, driving down the price of solar panels and lowering profits throughout the industry [25]. Germany has been considering a reduction of its solar FIT to avoid the same outcome.

Natural gas is the second fastest-growing source of power generation after renewables in the outlook for OECD Europe, increasing at an average rate of 1.3 percent per year from 2007 to 2035. Although growth still is strong, considering that total electricity demand increases by only 1.1 percent per year, it is slower than the 2.3-percent annual increase projected for natural-gas-fired generation in last year’s outlook. The difference results primarily from revised growth projections for the region’s nuclear and, to a lesser extent, renewable generation.

Nuclear power has gained renewed interest in Europe as concerns about greenhouse gas emissions and secure electricity supplies have increased. Electricity generation from nuclear power increases slightly over the projection period, as compared with a slight decrease in *IEO2009*. Many European nations that were previously opposed to nuclear power have revisited their stances, and Sweden and Italy reversed their nuclear policies in the first half of 2009. Further, Belgium has postponed its nuclear phaseout by 10 years [26], and the German government elected in September 2009 has announced its plans to rescind Germany’s phaseout policy [27].

Renewed interest and moves to reverse legislative bans on nuclear power have led to more license extensions and fewer retirements of operating nuclear power plants than were expected in previous outlooks. In addition, the *IEO2010* Reference case anticipates some new builds in France, Finland, Poland, Turkey, and possibly other countries of OECD Europe. As a result, OECD Europe’s

total nuclear capacity increases from 131 gigawatts in 2007 to 144 gigawatts in 2035.

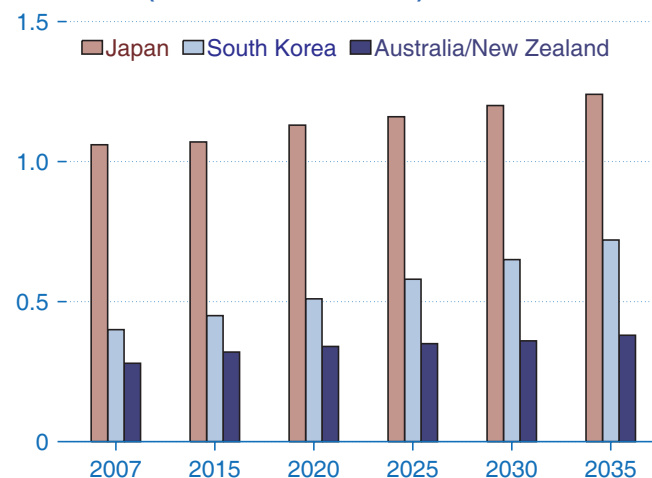
The new assessment of the potential for nuclear power in OECD Europe results in a substantial change in the projected fuel mix compared to last year’s outlook. In the *IEO2009* Reference case, natural gas generation in OECD Europe was expected to exceed nuclear generation in 2015, and in 2030 natural gas generation exceeded nuclear generation by nearly 40 percent. The *IEO2010* Reference case instead projects that regional nuclear generation will remain greater than natural-gas-fired generation until 2035, when electricity generation totals from the two sources are expected to be approximately equal.

Coal accounted for nearly 30 percent of OECD Europe’s net electricity generation in 2007, but concerns about the contribution of carbon dioxide emissions to climate change could reduce that share in the future. In the *IEO2010* Reference case, electricity from coal slowly loses its prominence in OECD Europe, decreasing by 0.3 percent per year from 2007 to 2035 and ultimately falling behind renewables, natural gas, and nuclear energy as a source of electricity.

OECD Asia

Total electricity generation in OECD Asia increases by an average of 1.0 percent per year in the Reference case, from 1.7 trillion kilowatthours in 2007 to 2.3 trillion kilowatthours in 2035. Japan accounts for the largest share of electricity generation in the region today and continues to do so in the mid-term projection, despite having the slowest-growing electricity market in the region and the slowest among all OECD countries, averaging 0.5 percent per year, as compared with 1.0 percent per year for Australia/New Zealand and 2.1 percent per year for South Korea (Figure 75). Japan’s electricity markets are well established, and its aging population and

Figure 75. Net electricity generation in OECD Asia, 2007-2035 (trillion kilowatthours)



relatively slow projected economic growth in the mid-term translate into slow growth in demand for electric power. In contrast, both Australia/ New Zealand and South Korea are expected to have more robust economic and population growth, leading to more rapid growth in demand for electricity.

The fuel mix for electricity generation varies widely among the three economies that make up the OECD Asia region. In Japan, natural gas, coal, and nuclear power make up the bulk of the current electric power mix, with natural gas and nuclear accounting for about 51 percent of total generation and coal another 31 percent. The remaining portion is split between renewables and petroleum-based liquid fuels. Japan's reliance on nuclear power increases over the projection period, from 24 percent of total generation in 2007 to 34 percent in 2035. The natural gas share of generation declines slightly over the same period, from 28 percent to 27 percent, and coal's share declines to 23 percent, being displaced by nuclear and—to a much smaller extent—renewable energy sources.

Solar power, increasing by 27.2 percent per year from 2007 to 2035, is Japan's fastest growing source of renewable electricity, although it starts from a negligible amount in 2007. A recipient of favorable government policies, the growth in solar power outpaces wind power, which increases by 3.8 percent per year. Both solar and wind power, however, remain minor sources of electricity, each supplying less than 1 percent of total generation in 2035, as compared with hydropower's 8-percent share.

Australia and New Zealand, as a region, rely on coal for about 70 percent of electricity generation, based largely on Australia's rich coal resource base (9 percent of the world's total coal reserves). The remaining regional generation is supplied by natural gas and renewable energy sources—mostly hydropower, wind, and, in New Zealand, geothermal. The Australia/New Zealand region uses negligible amounts of oil for electricity generation and no nuclear power, and that is not expected to change over the projection period. Natural-gas-fired generation is expected to grow strongly in the region, at 2.4 percent per year from 2007 to 2035, reducing the coal share to 58 percent in 2035.

In South Korea, coal and nuclear power currently provide 43 percent and 34 percent of total electricity generation, respectively. Natural-gas-fired generation grows quickly in the Reference case, but despite a near doubling of electricity generation from natural gas, its share of total generation increases only slightly, from 17 percent in 2007 to 18 percent in 2035. Coal and nuclear power continue to provide most of South Korea's electricity generation, with a combined 78 percent of total electricity in 2035.

Non-OECD electricity

Non-OECD Europe and Eurasia

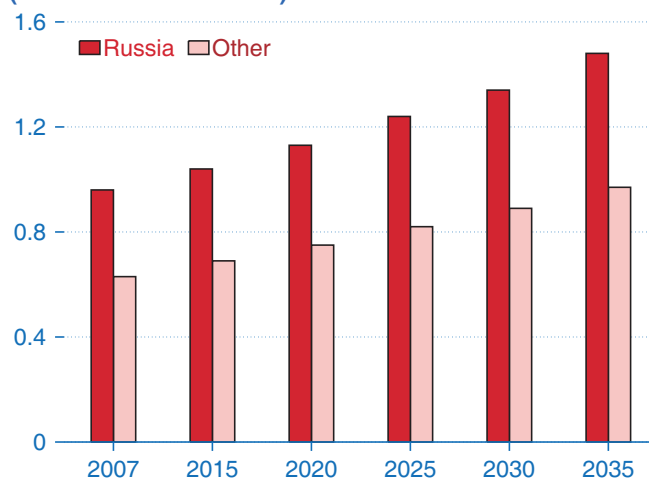
Total electricity generation in non-OECD Europe and Eurasia grows at an average rate of 1.6 percent per year in the *IEO2010* Reference case, from 1.6 trillion kilowatt-hours in 2007 to 2.2 trillion kilowatthours in 2030 and 2.5 trillion kilowatthours in 2035. Russia, with the largest economy in non-OECD Europe and Eurasia, accounted for around 60 percent of the region's total generation in 2007 and is expected to retain approximately that share throughout the period (Figure 76).

Natural gas and nuclear power supply much of the growth in electricity generation in the region. Although non-OECD Europe and Eurasia has nearly one-third of the world's total proved natural gas reserves, some countries, notably Russia, plan to export natural gas instead of burning it for electricity. As a result, natural-gas-fired generation grows modestly in the outlook, at an average annual rate of 1.2 percent from 2007 to 2035.

Generation from nuclear power grows strongly in the region, averaging 2.8 percent per year. Much of the increase is expected in Russia, which continues to shift generation from natural gas to nuclear because natural gas exports are more profitable than the domestic use of natural gas for electricity generation.

In 2006, the Russian government released Resolution 605, which set a federal target program for nuclear power development. Although the federal target program was updated and scaled back in July 2009 due to the recession, eight nuclear power reactors still are slated for completion by 2015 [28]. According to the Russian plan, an additional 40 reactors are to be constructed by 2030, raising Russia's nuclear generating capacity by 2 gigawatts per year from 2012 to 2014 and by 3 gigawatts per year from 2014 to 2020 [29]. This plan would

Figure 76. Net electricity generation in Non-OECD Europe and Eurasia, 2007-2035 (trillion kilowatthours)



bring total capacity to 40 gigawatts and increase nuclear generation to 25 or 30 percent of total generation in 2030 [30]. The *IEO2010* Reference case takes a more conservative view of the rate at which new nuclear power plants will come online in Russia and assumes some delay in meeting the current construction schedule. In the Reference case, Russia's existing 23 gigawatts of nuclear generating capacity is supplemented by a net total of 5 gigawatts by 2015 and another 20 gigawatts by 2035.

Renewable generation in non-OECD Europe and Eurasia, almost entirely from hydropower facilities, increases relatively slowly, by an average of 1.3 percent per year, largely as a result of repairs and expansions at existing sites. The repairs include reconstruction of turbines in the 6.4-gigawatt Sayano-Shushenskaya hydroelectric plant, which was damaged in an August 2009 accident that killed 75 people. Repairs are expected to be completed no earlier than 2012 [31]. Notable new projects include the 3-gigawatt Boguchanskaya Hydroelectric Power Station in Russia and the 3.6-gigawatt Rogun Dam in Tajikistan. Construction began on Boguchanskaya in 1980 and on Rogun in 1976, but work ceased when the former Soviet Union experienced economic difficulties in the 1980s. Despite the recent recession, construction continues on Boguchanskaya, which is on track for completion by 2012 [32]. In May 2008, Tajikistan's president announced that construction had resumed on Rogun Dam, although it is still uncertain how the large project will be financed [33]. Growth of nonhydropower renewable generation is projected to be small.

Non-OECD Asia

Non-OECD Asia—led by China and India—has the fastest projected regional growth in electric power generation worldwide, averaging 4.1 percent per year from 2007 to 2035 in the Reference case. Although the global economic recession has an impact on the region's short-term economic growth, in the long term the economies of non-OECD Asia are expected to expand strongly, with corresponding increases in demand for electricity in both the building and industrial sectors. Total electricity generation in non-OECD Asia rises by 42 percent from 2007 to 2015, from 4.8 trillion kilowatthours to 6.8 trillion kilowatthours. Electricity demand increases by 56 percent between 2015 and 2025, and by another 40 percent between 2025 and 2035. In 2035, net generation in non-OECD Asia totals 14.8 trillion kilowatthours in the Reference case.

Coal accounts for more than two-thirds of electricity generation in non-OECD Asia (Figure 77), dominated by generation in China and India. Both countries already rely heavily on coal to produce electric power. In 2007, coal's share of generation was an estimated 80 percent in China and 71 percent in India. Under existing policies, it

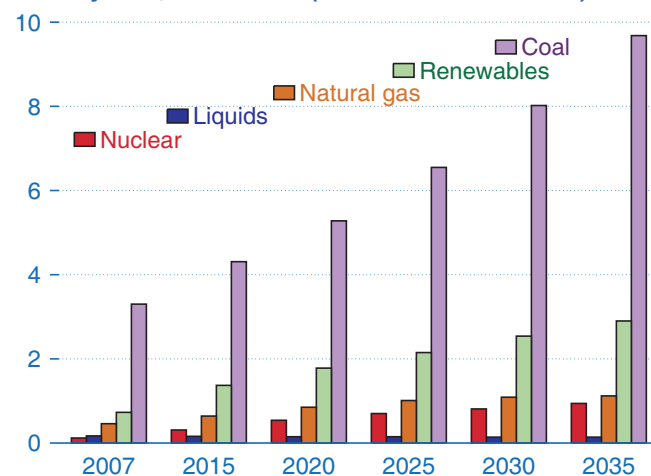
is likely that coal will remain the predominant source of power generation in both countries. In the *IEO2010* Reference case, coal's share of electricity generation declines to 74 percent in China and 51 percent in India in 2035.

Non-OECD Asia leads the world in installing new nuclear capacity in the *IEO2010* Reference case, accounting for 48 percent of the net increment in nuclear capacity worldwide (or 102 gigawatts of the total 211-gigawatt increase). China, in particular, has aggressive plans for nuclear power, with 21 nuclear power plants currently under construction and a total of 66 gigawatts of new capacity expected to be installed by 2035 [34]. The nuclear share of total generation in China increases from 2 percent in 2007 to 6 percent in 2035.

India also has plans to boost its nuclear power generation. From 4 gigawatts of installed nuclear power capacity in operation today, India has set an ambitious goal of increasing its nuclear generating capacity to 20 gigawatts by 2020 and to as much as 63 gigawatts by 2032 [35]. Five nuclear reactors are currently under construction, three of which are scheduled for completion by the end of 2010 [36]. The *IEO2010* Reference case assumes a somewhat slower increase in nuclear capacity than what is anticipated by India's government. The outlook projects that an additional 23 gigawatts of net installed capacity will become operational by 2035.

In addition to China and India, several other countries in non-OECD Asia are expected to begin or expand nuclear power programs. In the Reference case, new nuclear power capacity is installed in Vietnam, Indonesia, and Pakistan by 2020. The impact of high fossil fuel prices, combined with concerns about security of energy supplies and greenhouse gas emissions, leads many nations in the region to consider diversifying the fuel mix for their power generation by adding a nuclear component.

Figure 77. Net electricity generation in Non-OECD Asia by fuel, 2007-2035 (trillion kilowatthours)



Electricity generation from renewable energy sources in non-OECD Asia grows at an average annual rate of 5.0 percent, increasing the renewable share of the region's total generation from 15 percent in 2007 to 20 percent in 2035. Small-, mid-, and large-scale hydroelectric facilities all contribute to the projected growth. Several countries in non-OECD Asia have hydropower facilities either planned or under construction, including Vietnam, Malaysia, Pakistan, and Myanmar (the former Burma). Almost 50 hydropower facilities, with a combined 3,398 megawatts of capacity, are under construction in Vietnam's Son La province, including the 2,400-megawatt Son La and 520-megawatt Houi Quang projects, both of which are scheduled for completion before 2015 [37]. Malaysia expects to complete its 2,400-megawatt Bakun Dam by 2011, although the project has experienced delays and setbacks in the past [38]. Pakistan and Myanmar also have substantial hydropower development plans, but those plans have been discounted in the *IEO2010* Reference case to reflect the two countries' historical difficulties in acquiring foreign direct investment for infrastructure projects.

India has plans to more than double its installed hydropower capacity by 2030. In its Eleventh and Twelfth Five-Year Plans, which span 2007 through 2017, India's Central Electricity Authority has identified 40.9 gigawatts of hydroelectric capacity that it intends to build. Although the *IEO2010* Reference case does not assume that all the planned capacity will be completed, more than one-third of the announced projects are under construction already and are expected to be completed by 2020 [39].

India's federal government is attempting to provide incentives for the development of hydropower across the nation. Legislation has been proposed to allow private hydroelectric power developers to be eligible over a 5-year period for a tariff that would guarantee a fixed return on investment and allow generators to improve their returns by selling up to 40 percent of their electricity on the spot market. In addition, India's federal hydropower intentions are being supported by state authorities. The state government in Himachal Pradesh has plans to commercialize a substantial portion of the state's reported 21 gigawatts of hydroelectric power potential, adding 5.7 gigawatts of hydroelectric capacity before 2015, which would nearly double the existing capacity [40]. At the end of 2009, 11 projects with a combined installed capacity of 4.4 gigawatts were in development in Himachal Pradesh [41].

Similar to India, China also has many large-scale hydroelectric projects under construction. The 18.2-gigawatt Three Gorges Dam project's final generator went on line in October 2008, and the Three Gorges Project Development Corporation plans to further increase the project's total installed capacity to 22.4 gigawatts by 2012 [42]. In

addition, work continues on the 12.6-gigawatt Xiluodu project on the Jinsha River, which is scheduled for completion in 2015 as part of a 14-facility hydropower development plan [43]. China also has the world's second tallest dam (at nearly 985 feet) currently under construction, as part of the 3.6-gigawatt Jinping I project on the Yalong River. It is scheduled for completion in 2014 as part of a plan by the Ertan Hydropower Development Company to construct 21 facilities with 34.6 gigawatts of hydroelectric capacity on the Yalong [44].

The Chinese government has set a 300-gigawatt target for hydroelectric capacity in 2020. Including those mentioned above, the country has a sufficient number of projects under construction or in development to meet the target. China's aggressive hydropower development plan is expected to increase hydroelectricity generation by 3.9 percent per year, almost tripling the country's total hydroelectricity generation by 2035.

Although hydroelectric projects dominate the renewable energy mix in non-OECD Asia, generation from nonhydroelectric renewable energy sources, especially wind, is also expected to grow significantly. At the end of 2008, China completed installation of its 10th gigawatt of wind capacity, achieving its 2010 target a full year ahead of the schedule set out by the National Development and Reform Commission [45]. In May 2009, China increased its 2020 wind capacity target from 30 gigawatts to 100 gigawatts [46]. Although that goal has been discounted in the *IEO2010* Reference case because of indications that up to one-third of Chinese installed wind capacity is not grid-connected [47], the new target is expected to significantly increase the rate of wind farm construction. In the *IEO2010* Reference case, electricity generation from wind plants in China grows by 15.6 percent per year, from 6 billion kilowatthours in 2007 to 374 billion kilowatthours in 2035.

New government policies in China and India are also encouraging the growth of solar generation. Under its "Golden Sun" program, announced in July 2009, the Chinese Ministry of Finance plans to subsidize 50 percent of the construction costs of grid-connected solar plants [48]. India's National Solar Mission, launched in November 2009, aims to have 20 gigawatts of installed solar capacity (both PV and solar thermal) by 2020, 100 gigawatts by 2030, and 200 gigawatts by 2050 [49]. India's targets have been discounted in the *IEO2010* Reference case because of the substantial uncertainty about the future of government-provided financial incentives [50]. However, the policies support robust growth rates in solar generation for China and India, at 19 percent per year and 27 percent per year, respectively, in the *IEO2010* Reference case.

Geothermal energy, while a small contributor to non-OECD Asia's total electricity generation, plays an

important role in the Philippines and Indonesia. With the second largest amount of installed geothermal capacity in the world, the Philippines generated almost 18 percent of its total electricity from geothermal sources in 2008 [51]. Indonesia, with the fifth largest installed geothermal capacity, generated 5 percent of its electricity from geothermal energy in 2007 and has more than 20 gigawatts of geothermal potential available [52]. Both the Philippines and Indonesia have announced plans to increase their installed geothermal capacities in the coming years. Indonesia's plans include 3.9 gigawatts of net installed capacity that it intends to build by 2014 [53].

Middle East

Electricity generation in the Middle East region grows by 2.5 percent per year in the Reference case, from 0.7 trillion kilowatthours in 2007 to 1.3 trillion kilowatthours in 2035. The region's young and rapidly growing population, along with a strong increase in national income, is expected to result in rapid growth in demand for electric power. Iran, Saudi Arabia, and the United Arab Emirates (UAE) account for two-thirds of the regional demand for electricity, and demand has increased sharply over the past several years in each of the countries. From 2000 to 2007, Iran's net generation increased by an average of 7.9 percent per year; Saudi Arabia's by 6.1 percent per year; and the UAE's by 9.6 percent per year.

The Middle East depends on natural gas and petroleum liquid fuels to generate most of its electricity and is projected to continue that reliance through 2035 (Figure 78). In 2007, natural gas supplied 57 percent of electricity generation in the Middle East and liquid fuels 35 percent. In 2035, the natural gas share is projected to be 68 percent and the liquid fuels share 21 percent. There has been a concerted effort by many of the petroleum

exporters in the region to develop their natural gas resources for use in domestic power generation. Petroleum is a valuable export commodity for many nations in the Middle East, and there is increasing interest in the use of domestic natural gas for electricity generation in order to make more oil assets available for export.

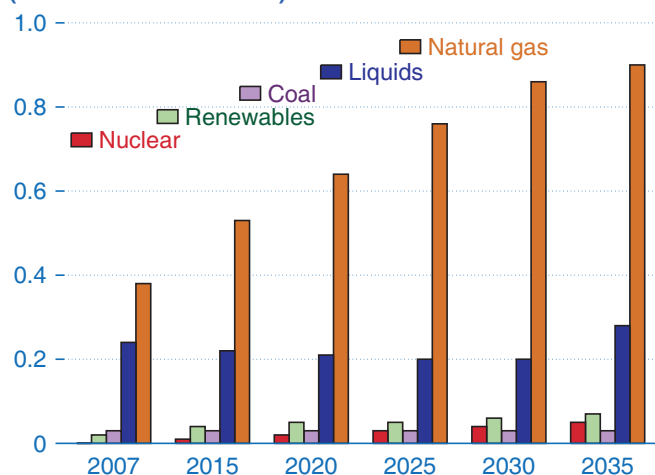
Other energy sources make only minor contributions to electricity supply in the Middle East. Israel is the only country in the region that uses significant amounts of coal to generate electric power [54], and Iran and the UAE are the only ones projected to add nuclear capacity. Other Middle Eastern countries recently have expressed some interest in increasing both coal-fired and nuclear generation, however, in response to concerns about diversifying the electricity fuel mix and meeting the region's fast-paced growth in electricity demand. For example, Oman announced in 2008 that it would construct the Persian Gulf's first coal-fired power plant at Duqm [55]. According to the plan, the 1-gigawatt plant will power a water desalinization facility and will be fully operational by 2016 [56]. The UAE, Saudi Arabia, and Bahrain also have considered adding coal-fired capacity [57].

In addition to Iran, several other Middle Eastern nations have announced intentions to pursue nuclear power programs in recent years. In 2007, the six-nation Gulf Cooperation Council²² completed a feasibility study, in cooperation with the International Atomic Energy Agency, of the potential for a regional nuclear power and desalinization program, while also announcing their intention to pursue a peaceful nuclear program [58].

The UAE government in 2008 announced plans to have three 1.5-gigawatt nuclear power plants completed by 2020 and has since signed nuclear cooperation agreements with France, Japan, the United Kingdom, and the United States [59]. In December 2009, the Emirates Nuclear Energy Corporation in the UAE selected a South Korean consortium to build four nuclear reactors, with construction planned to begin in 2012 [60]. Jordan also has announced its intention to add nuclear capacity [61], and in 2009 the Kuwaiti cabinet announced that it would form a national committee on nuclear energy use for peaceful purposes [62]. Even given the considerable interest in nuclear power that has arisen in the region, however, *IEO2010* expects that economic and political issues, in concert with the long lead times usually associated with beginning a nuclear program, will mean that any reactors built in the Middle East over the course of the projection will be located in Iran or the UAE.

Although there is little economic incentive for countries in the Middle East to increase their use of renewable energy sources (the renewable share of the region's total

Figure 78. Net electricity generation in the Middle East by fuel, 2007-2035 (trillion kilowatthours)



²²Gulf Cooperation Council members are Saudi Arabia, Kuwait, Bahrain, the United Arab Emirates, Qatar, and Oman.

electricity generation increases from only 3 percent in 2007 to 5 percent in 2035 in the Reference case), there have been some recent developments in renewable energy use in the region. Iran, which generated 10 percent of its electricity from hydropower in 2009, is developing 94 new hydroelectric power plants, 5 of which are expected to come on line before March 2010 [63]. Construction also continues on Masdar City in Abu Dhabi, a “zero carbon” city that will be powered by 190 megawatts of PV cells and 20 megawatts of wind power [64]. The city, which was chosen as the interim headquarters of the International Renewable Energy Agency and currently has a 10-megawatt PV array, is on track to be completed in 2016 [65].

Africa

Demand for electricity in Africa grows at an average annual rate of 2.6 percent in the *IEO2010* Reference case. Fossil-fuel-fired generation supplied 81 percent of the region’s total electricity in 2007, and reliance on fossil fuels is expected to continue through 2035. Coal-fired power plants, which were the region’s largest source of electricity in 2007, accounting for 45 percent of total generation, provide a 39-percent share in 2035; and natural-gas-fired generation expands strongly, from 25 percent of the total in 2007 to 39 percent in 2035 (Figure 79).

At present, South Africa’s two nuclear reactors are the only commercial reactors operating in the region, accounting for about 2 percent of Africa’s total electricity generation. Reports suggest that, due to Eskom’s finance problems and the termination of government funding, the construction of a new Pebble Bed Modular Reactor in South Africa will be delayed indefinitely [66]. The South African government plans to have another 4 gigawatts of nuclear capacity on line by mid-2018. In addition, Egypt’s government has plans to construct a nuclear reactor, having signed a nuclear power cooperation agreement with Russia in 2008 and awarded a contract

to U.S.-based Bechtel to design the new power plant, with tentative plans for a location at Dabaa, about 100 miles west of Alexandria [67]. In the Reference case, 2.3 gigawatts of net nuclear capacity becomes operational in Africa over the 2007-2035 period, although only South Africa is expected to complete construction of any reactors. The nuclear share of the region’s total generation increases to 3 percent in 2035.

Generation from hydropower and other marketed renewable energy sources is expected to grow relatively slowly in Africa. As they have in the past, non-marketed renewables are expected to continue providing energy to Africa’s rural areas; however, it is often difficult for African nations to find funding or international support for larger commercial projects. Plans for several hydroelectric projects in the region have been advanced recently, and they may help boost supplies of marketed renewable energy in the mid-term. Several (although not all) of the announced projects are expected to be completed by 2035, allowing the region’s consumption of marketed renewable energy to grow by 2.2 percent per year from 2007 to 2035. For example, Ethiopia finished work on two hydroelectric facilities in 2009: the 300-megawatt Takeze power station and the 420-megawatt Gilgel Gibe II. A third plant, the 460-megawatt Tana Beles, is expected to be operational in the first half of 2010 [68].

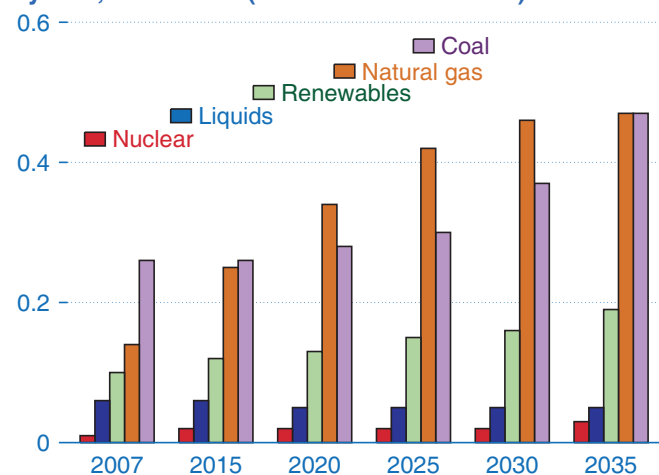
Central and South America

Electricity generation in Central and South America increases by 2.1 percent per year in the *IEO2010* Reference case, from 1.0 trillion kilowatthours in 2007 to 1.7 trillion kilowatthours in 2030 and 1.8 trillion kilowatthours in 2035. The recent global economic crisis slowed the region’s economies and lowered demand for electricity, especially in the industrial sector. In the longer term, however, the region’s electricity markets are expected to return to trend growth as the economic difficulties recede.

The fuel mix for electricity generation in Central and South America is dominated by hydroelectric power, which accounted for nearly two-thirds of the region’s total net electricity generation in 2007. Of the top seven electricity-generating countries in the region, five—Brazil, Venezuela, Paraguay, Colombia, and Peru—generate more than 65 percent of their total electricity from hydropower.

In Brazil, the region’s largest economy, hydropower provided almost 85 percent of electricity generation in 2007 (Figure 80). The country has been trying to diversify its electricity generation fuel mix away from hydroelectric power because of the risk of power shortages during times of severe drought. In the Brazilian National Energy Plan for 2008-2017, the government set a goal to build 54 gigawatts of installed capacity, with

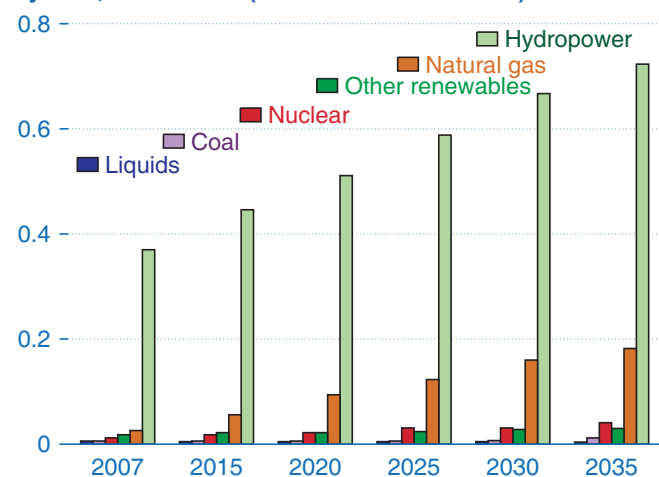
Figure 79. Net electricity generation in Africa by fuel, 2007-2035 (trillion kilowatthours)



nonhydroelectric capacity making up the majority of additions [69]. To achieve that target, the government has announced plans to increase nuclear power capacity, beginning with the completion of the long-idled 1.3-gigawatt Angra-3 project [70]. Construction was delayed in 2009 but is now scheduled to begin in February 2010. According to the plan, the reactor is slated to begin coming on line in mid-2015 [71]. Brazil also has plans to construct four additional 1-gigawatt nuclear plants beginning in 2015. In the *IEO2010* Reference case, the Angra-3 project is completed by 2015, and three more planned nuclear projects are completed by 2035.

In the past, the Brazilian government has tried relatively unsuccessfully to attract substantial investment in natural-gas-fired power plants. Its lack of success has been due mostly to the higher costs of natural-gas-fired generation relative to hydroelectric power, and to concerns about the security of natural gas supplies. Brazil has relied on imported Bolivian natural gas for much of its supply, but concerns about the impact of Bolivia's nationalization of its energy sector on foreign investment in the country's natural gas production has led Brazil to look toward LNG imports for secure supplies. Brazil has invested strongly in its LNG infrastructure, and its third LNG regasification plant is scheduled for completion in 2013 [72]. With Brazil diversifying its natural gas supplies, substantially increasing domestic production, and resolving to reduce the hydroelectric share of generation, natural gas is projected to be its fastest-growing source of electricity, increasing by 7.2 percent per year on average from 2007 to 2035.

Figure 80. Net electricity generation in Brazil by fuel, 2007-2035 (trillion kilowatthours)

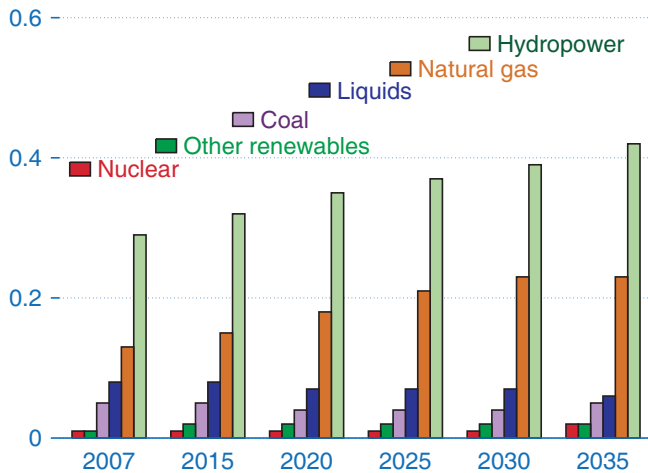


Brazil still has plans to continue expanding its hydroelectric generation over the projection period, including the construction of two plants on the Rio Madeira in Rondonia—the 3.2-gigawatt Santo Antonio and the 3.3-gigawatt Jirau hydroelectric facilities. The two plants, with completion dates scheduled for 2012-2015, are expected to help Brazil meet electricity demand in the mid-term [73]. In the long term, electricity demand could be met in part by the proposed 11.2-gigawatt Belo Monte dam; its tender has been delayed until April 2010 [74]. Each of these three projects could, however, be subject to further delay as a result of legal challenges.

Brazil is also interested in increasing the use of other, nonhydroelectric renewable resources in the future—notably, wind. In December 2009, Brazil held its first supply tender exclusively for wind farms. At the event, 1.8 gigawatts of capacity were purchased, for development by mid-2012 [75]. In a signal that wind power may become more economically competitive in Brazil, the average price of the power sold was 21 percent lower than the ceiling price set by the government. In the *IEO2010* Reference case, wind power generation in Brazil grows by 9.0 percent per year, from 530 million kilowatthours in 2007 to 5,990 million kilowatthours in 2035. Despite that robust growth, however, wind remains a modest component of Brazil's renewable energy mix in the Reference case, as compared with the projected growth in hydroelectric generation to 723 billion kilowatthours in 2035.

Several other nations in Central and South America have been trying to increase the amounts of natural gas used in their generation fuel mixes by increasing both pipeline and LNG supplies. Chile, for instance, relies on Argentina for its natural gas supplies, but beginning in 2004, Argentina began to restrict its exports after it was unable to meet its own domestic supply. As a result, Chile has been forced to use diesel-fueled electric generating capacity periodically to avoid power outages during the winter months [76]. In response to the lack of a secure source of natural gas from Argentina, Chile began construction on two LNG regasification projects. The Quintero facility became operational in June 2009, and the second facility, Mejillones, is scheduled for completion by the end of 2010. In the *IEO2010* Reference case, natural-gas-fired generation in Central and South America (excluding Brazil) increases by an average 2.2 percent per year, and the natural gas share of total electricity generation rises from 22 percent in 2007 to 29 percent in 2035 (Figure 81).

Figure 81. Net electricity generation in Other Central and South America by fuel, 2007-2035 (trillion kilowatthours)



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